



# Part 3: Conventional and Emerging Technology Applications for Utilizing Landfill Gas

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# Presentation Outline

- **Direct Gas Use/Sale**
- **Electricity Generation**
- **Pipeline Upgrades**
- **Leachate Evaporation**
- **Micro Turbines**
- **Vehicle Fuel**
- **Fuel Cells**
- **Greenhouses**
- **Other Technologies**
- **Conclusions**



# Why Use Landfill Gas?

- Local, available fuel source
- Easy to capture and use
- Source of renewable energy
- Constant supply, 24 hours a day, 7 days a week
- Reliable technologies exist for using landfill gas
- Uses a source of energy that otherwise would have been wasted
- Helps the environment by reducing uncontrolled emissions of landfill gas

# Direct Gas Utilization



- **Gas piped to a nearby customer for use in boiler**
- **118 projects in the US**
- **Pipeline length range from .6 - 5 kilometers**
  - **less than 3km is most feasible**
- **Gas used on-site**



***Cleaver Brooks 20,000 lb/hr Boiler***

# Advantages and Disadvantages



- **Advantages**
  - Simple technology
  - Minimal processing requirements
  - Most cost effective
- **Disadvantages**
  - Requires locating a customer within close proximity of the landfill
  - Right of way permits
  - Local terrain not conducive to pipeline installation

# Costs

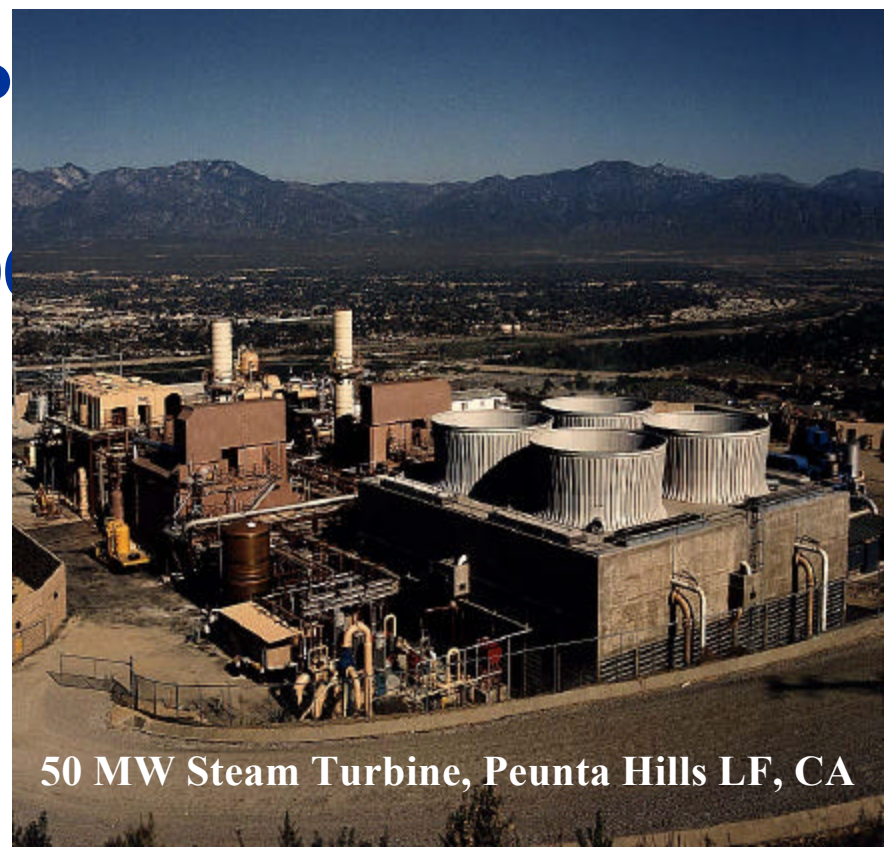


- **US\$1.50 (3.57 Real) to \$3.50 (8.33 Real) per MMBtu, depending on:**
  - **Pipeline length**
  - **Collection system in-place at landfill**
- **Other costs**
  - **Boiler retrofit**
  - **Operation and Maintenance**



# Electricity Generation

- **Most prevalent in the US**
  - In US, 900 MW from over 200 operational projects
- **Electricity sold to utility or nearby customer**
- **Average project size: 500 kW - 50 MW**
- **Technologies**
  - Internal Combustion (IC) Engine, 1-3MW
  - Gas Turbine, 3-10MW



50 MW Steam Turbine, Peunta Hills LF, CA

# Advantages, Disadvantages and Costs: IC Engine



- **Advantages**

- low cost
- High efficiency
- most common technology

- **Disadvantages**

- Problems due to particulate matter buildup
- Corrosion of engine parts and catalysts
- High NO<sub>x</sub> emissions

- **Costs**

- US\$1,100-1,300 (\$/kW)  
(2600 - 3100 Real per kW)



*Caterpillar 3516 800 kW genset*



# Advantages, Disadvantages and Costs: Gas Turbine

- **Advantages**

- Corrosion resistant
- Low O&M costs
- small physical size
- Low NO<sub>x</sub> emissions

- **Disadvantages**

- Inefficient at part load
- High parasitic loads, due to high gas compression requirements

- **Costs**

- US\$1,200-1,700 (\$/kW)
- (\$2800 - 4000 Real per kW)

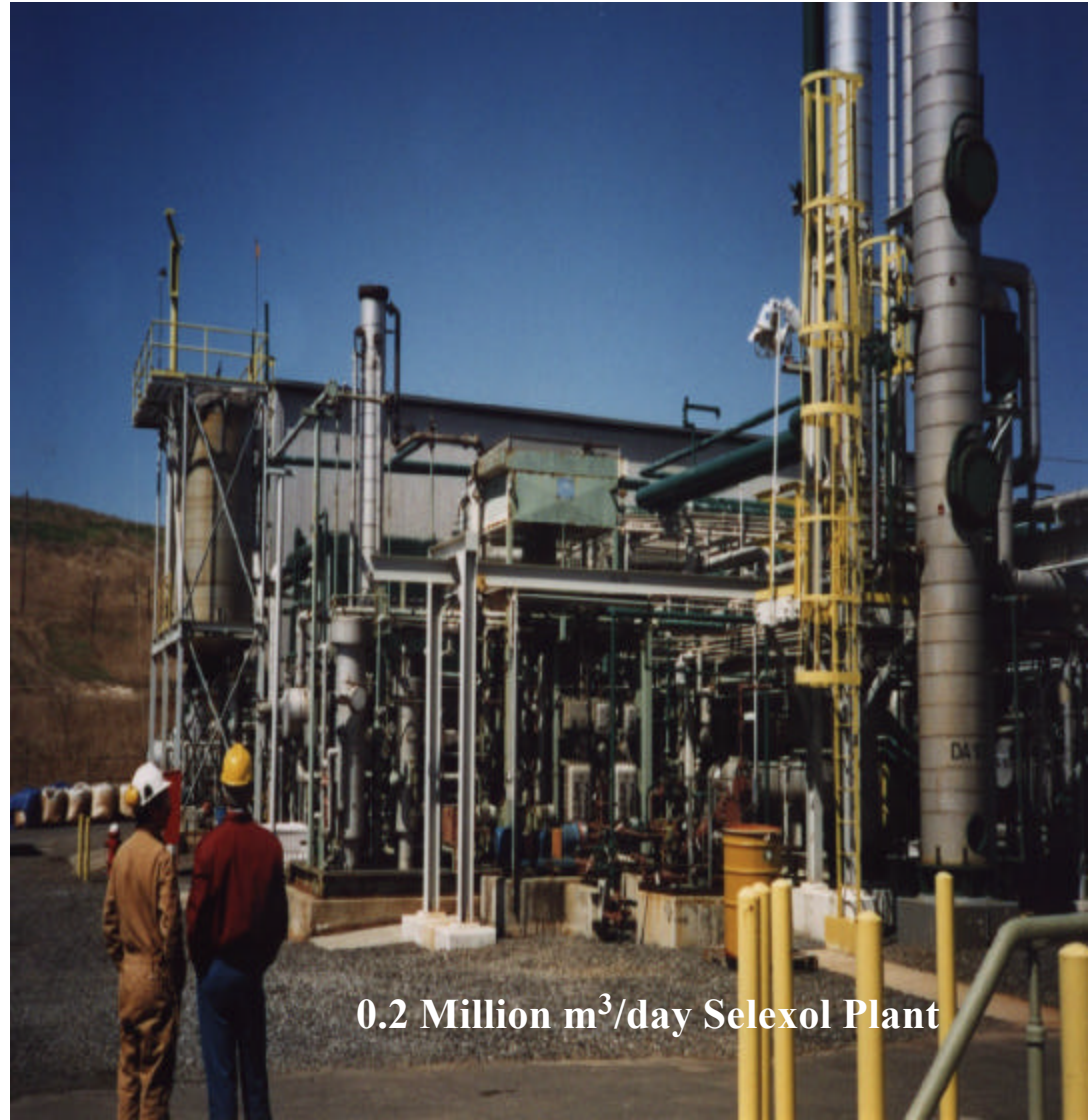


Solar 3 MW Gas Turbine

# Pipeline Quality Gas Upgrade



- **Gas is upgraded to a medium or high quality gas product**
- **Injected into a natural gas pipeline**
- **Generally at landfills with greater gas flows**
- **11 operational projects in the US**



0.2 Million m<sup>3</sup>/day Selexol Plant

# Advantages, Disadvantages and Costs



- **Advantages**

- All gas recovered from the landfill is used
- Cost effective for landfills with high volumes of gas
- Beneficial in areas where natural gas prices are high

- **Disadvantages**

- Extensive treatment of landfill gas
- Additional quality control requirements
- Higher capital costs
- Higher compression of gas is required

- **Costs**

- US\$3.60 to \$4.15 per MMBtu (\$8.60 to 9.90 Real per MMBtu)



# Leachate Evaporation



- **Utilize LFG to treat leachate**
- **Commercially available technology**
- **Units operating in the US and internationally**



# Advantages and Disadvantages

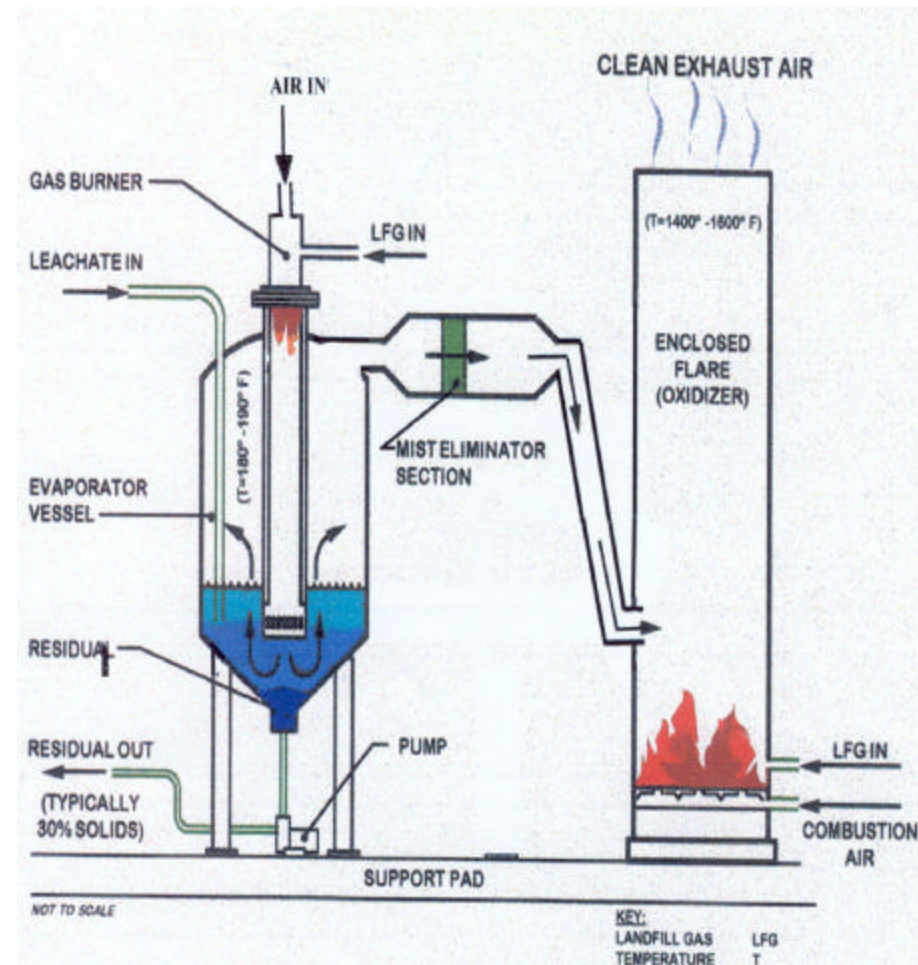


## ● Advantages

- Applicable to landfills that have limited leachate treatment options and high leachate disposal costs
- Proven technology
- Meets local air quality requirements

## ● Disadvantages

- More expensive than traditional landfill leachate treatment options
- Generally applicable to larger landfill sites

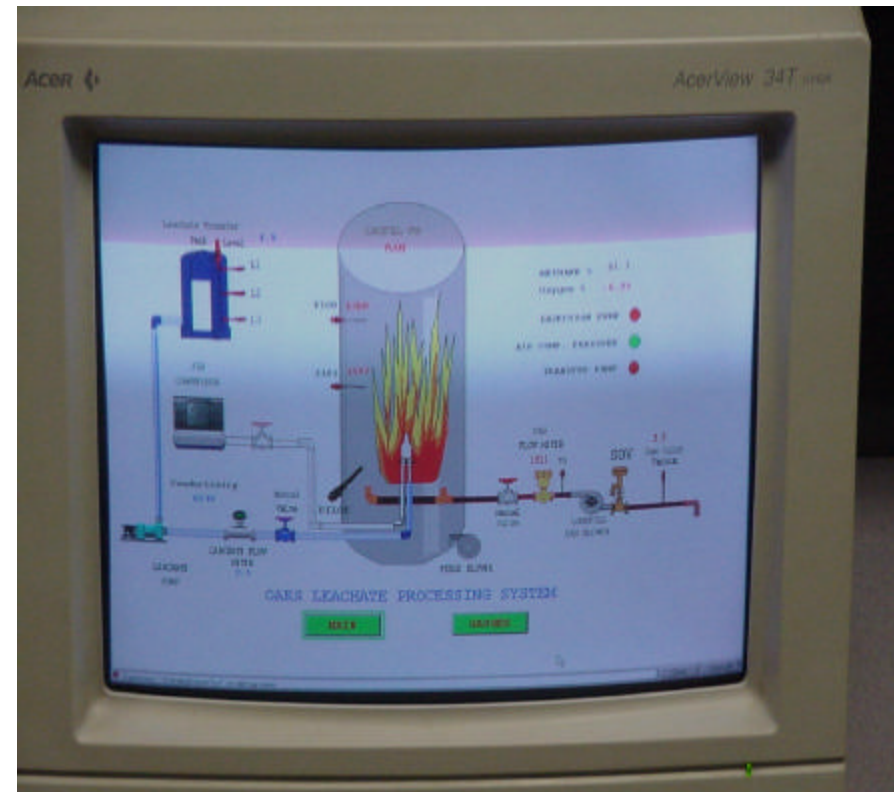




# Costs



- **Capital Cost**
  - 10,000 gpd facility:  
US\$295,000 (702,100 Real)
  - 20,000 gpd facility:  
US\$485,000 (1,154,000 Real)
- **O&M Cost**
  - 10,000 gpd facility:  
US\$70,000 (166,600 Real)
  - 20,000 gpd facility:  
US\$95,000 (226,100 Real)



# Vehicle Fuel



- **Compressed landfill gas (CNG)**
- **Liquefied landfill gas (LNG) - CryoFuels®**
- **Early stages of commercial development**



# Advantages and Disadvantages



- **Advantages**

- **LNG/CNG price lower than diesel fuel cost**
- **Reduction in use of fossil fuels**
- **Reduce local ozone pollution**

- **Disadvantages**

- **Very small percentage of alternative-fuel vehicles**
- **Vehicle conversion costs**
- **Limited track record of performance**





# Costs



- **Retrofit vehicles = \$3,500 to \$4,000 (8,300 to 9500 Real) per vehicle**
- **Fueling station = \$1,000,000 (2,380,000 Real)**
- **Fuel price = \$.48 to \$1.26 (1.15 to 3.50 Real) per gallon**



# Micro Turbines



- **A high speed turbo-charged generator that produces stationary power**
- **Has been used in aviation for some time**
- **Available in sizes ranging between 25kW to 75 kW**



Allied Signal Parallon 75



# Advantages and Disadvantages



- **Advantages**

- **Low emissions**
- **Multiple fuel capability**
- **Light weight/small size**
- **Does not require any pretreatment of the fuel**
- **Lower maintenance costs**

- **Disadvantages**

- **Low efficiencies**
- **Has been tested mostly for natural gas applications**
- **Limited track record of performance**

# Costs

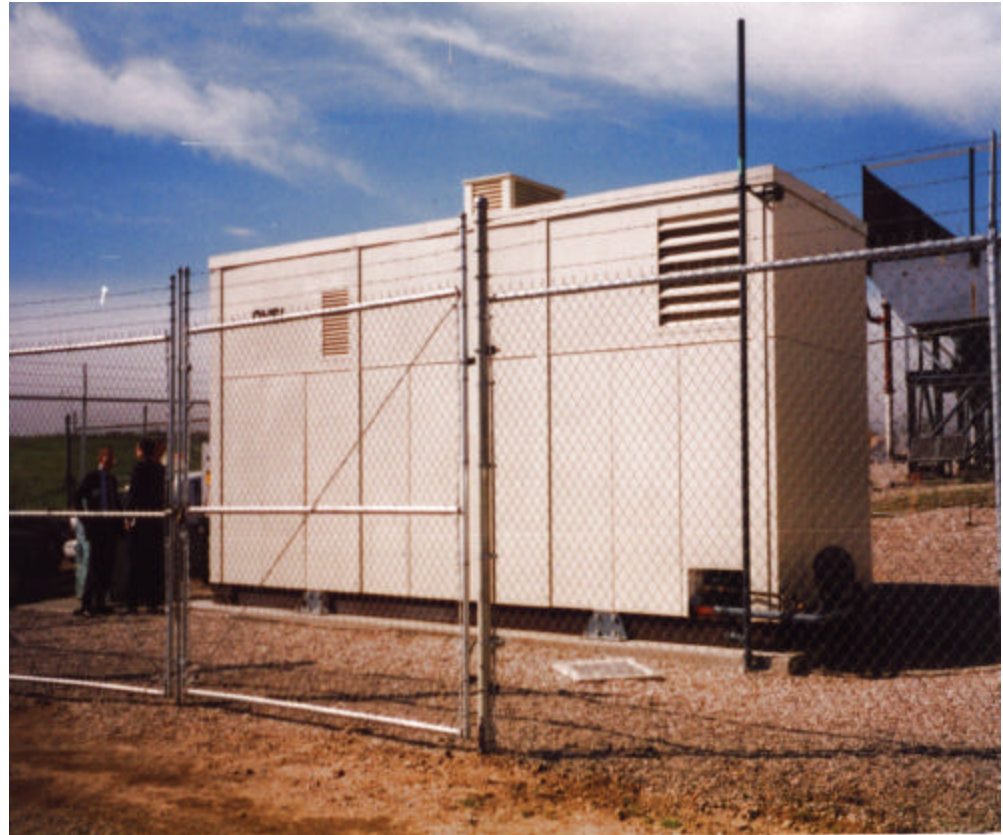


- **Capital Cost**
  - **\$700 to \$1200 (1660 to 3350 Real) per kW**
  - **Cost is expected to reduce to half in the next five years**
- **O&M Cost**
  - **< \$0.01 (0.02 Real) per kWh**

# Fuel Cells



- **Chemically convert gas to electricity**
- **Demonstration phase technology**



# Advantages



- **Advantages**
  - **Low emissions**
  - **Reduction in use of fossil fuels**
- **Disadvantages**
  - **High cost**
  - **Limited track record of performance**

# Costs



- **Approximately \$3,000 (7140 Real) per kW**
- **200 kW demonstration unit at California landfill = US\$1.5 million (3,500,000 Real)**



# Greenhouses



- **Applicable to smaller landfills**
- **Produce high purity carbon dioxide**



# Advantages and Disadvantages



- **Advantages**

- Meets energy needs of greenhouse
- Increasing competition and shrinking profit margins shifts focus to energy efficiency
- Cost effective production of warm weather crops in otherwise cost-prohibitive growing seasons

- **Disadvantages**

- Requires locating a greenhouse in close proximity of a landfill
- Seasonal variability

# Costs



- **A project in the U.S. estimated that it costs US\$4.80 (11.40 Real) per MMBtu**
- **Limited cost information is available**

# Technologies of the Future



- **Thermal Hybrid Electric (THE) Sun Dish**
  - Dual “fuel” Stirling-cycle engine
  - Combines solar and LFG power
  - Research and development scale technology



# Advantages and Disadvantages



- **Advantages**
  - **High-efficiency solar system**
  - **Low emissions**
  - **Reduction in use of fossil fuels**
- **Disadvantages**
  - **High cost**
  - **Limited track record of performance**
  - **Only suitable for certain locations**
  - **Small output capacity**



# Costs



- **Not commercially available at this time**



# Summary



- **Many ways to beneficially utilize LFG**
- **Available niche technologies range from research and development stage units to commercially available systems**
- **Technologies exist for low and high volumes of LFG production**
- **Selection of technology is project specific**

# Summary, continued....



- **Key Selection Considerations Include:**
  - **Environmental performance**
  - **Reliability**
  - **Accuracy of assumptions**
  - **Permitting issues**
    - emissions
  - **Cost**

